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16. ABSTRACT

Estimates of excess human mortality during episodes of extreme temperature in the United States are complicated by two serious limitations in available health data. First, initial post-episode investigations are usually incomplete, concentrated on mortality in one or two major urban population centers, while rural, suburban or small urban populations are overlooked. Second, criteria for death certificate classification of heat stroke or hypothermia as immediate cause of death are not consistent between health departments. Strick practices at some localities require an antemortem examination before heat stroke can be certified, resulting in classification of dead-on-arrival victims as cardiovascular, stroke or other apparently non-temperature specific causes, while localities that permit more discretion to physicians or medical examiners yield persistently higher numbers of temperature-related deaths.

A procedure is developed to avoid the present limitations by generation of a statistical standard of daily expected mortality for specific populations utilizing an available 10-year computer data base. Excess mortality would be the number of observed deaths greater than the standard, coincident with days of extreme heat or cold, with regard to cause classification. Mortality standards are generated and tested for all populations affected by heat waves and cold waves in the periods 1962-1966, 1973-1977.

17. KEY WORDS AND DOCUMENT ANALYSIS

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Mortality, heat stress, cold stress		

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A MORTALITY STANDARD FOR HEAT WAVE AND COLD WAVE EPISODES

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1. INTRODUCTION

Weather conditions of extreme heat or cold have long been linked to increased mortality in affected populations. The World Health Organization (1965) has published the International Classification of Diseases (ICD) which recognizes two causes of death, excess heat (heat stroke, heat exhaustion, apoplexy, etc., ect.), and excess cold (hypothermia, exposure, etc., ect.) associated with such episodes. Standard certificates of death issued by the National Center for Health Statistics, to which most states conform, provide for certification of cause of death with multiple specifications. The first specification, immediate cause, refers to the cause leading directly to death, and the second or third specification refer to antecedent conditions that gave rise to the immediate cause, with the underlying cause last. It is the underlying cause that is considered most significant and is translated into the vital statistics data base of the United States.

Unfortunately, under most health department procedures, a death involving extreme heat or cold is seldom classified as such because it is rare for either to be an underlying cause. This problem was noted and commented upon by Oeschsli and Buechley (1965) in an investigation of heat wave mortality in the Los Angeles region, and also by Bridger and Helfand (1968) in a study of the July 1966 heat wave in the State of Illinois. The California study agreed with most researchers that increased mortality in a heat wave tends to follow maximum temperatures by one day - the day it takes to overwork a tired circulatory system. However, most deaths were assigned to coronary and cerebrovascular disease, and excess heat classifications were almost absent. The authors of the Illinois study concluded it was necessary to investigate occurrence of all classifications of diseases to determine heat-related deaths.

An investigation of the July 1980 heat wave by the Centers for Disease Control, Atlanta, conducted by Jones (1982) involved a review of all death certificates, hospital, emergency room, and medical examiners' records in St. Louis and Kansas City, Missour. Such an intensive effort was required in part by the knowledge that vital statistics from death certificate data overlook a large number of heat-related deaths.

*On assignment from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

2. DATA AND PROCEDURE

The availability of a computer data base of vital statistics of 10-years of daily mortality from the National Center for Health Statistics afforded an opportunity to investigate variations of mortality during periods of extreme temperatures with the objective of developing a procedure to avoid the current limitations in assessment of the full impact upon populations.

An example of how rarely excess cold or heat is certified as cause of death in the United States can be obtained from the computer data base as illustrated in Table 1.

Table 1. Numbers of deaths in the United States

Year	Excessive heat	Excessive cold	All Causes
1962	154	423	1,756,449
1963	196	457	1,813,199
1964	195	287	1,797,528
1965	106	298	1,827,776
1966	531	365	1,862,985
.....			
1973	182	383	1,972,827
1974	143	348	1,934,154
1975	194	360	1,892,674
1976	102	427	1,909,294
1977	315	635	1,899,476

An unusually high number of excess heat deaths in 1966 is associated with the heat wave of July 1966, and the number, 531, illustrates the problem of finding an accurate value for heat-related mortality. For the State of Illinois alone, Bridger and Helfand (1968) estimated 1,148 excess deaths when compared to a "reference summer" of July 1965, and a study of the same heat wave by Henschel (1968) in the City of St. Louis, Missouri, concluded heat was the cause of death in 246 cases and a strong contributor to 40 or more. Moreover, when excessive deaths are arranged by locality there is evidence that criteria for classification are not uniform between health departments.

Table 2 illustrates the effect of different criteria for classification of excessive heat deaths between localities within the same state.

Table 2. Classified excessive heat deaths July 1 to 18, 1966

Missouri		
City of St. Louis		135
County of St. Louis		9
Remainder of Missouri		26
	Total	170
Illinois		
St. Clair Co. (East St. Louis)		17
Madison Co. (Granite City)		9
Sangamon Co. (Springfield)		5
Cook Co. (Chicago)		5
Remainder of Illinois		24
	Total	60

An explanation of the high number of excessive heat deaths at St. Louis was suggested by Jones (1982) in an investigation of the July 1980 heat wave, when he found that it was the practice at Kansas City to require an antemortem examination before classification of heatstroke as underlying cause, while St. Louis did not. The result of this practice was that most dead-on-arrival victims at Kansas City were classified as other than excessive heat. In July 1980, St. Louis reported 43 heatstroke fatalities; Kansas City reported only 2 heatstroke deaths. Unfortunately, criteria applied at Kansas City appears to represent current classification procedures throughout the United States with a result of a serious underestimation of heat-related deaths. Also, since many of the victims are elderly and very likely suffering from a chronic disease, there is a tendency to classify the chronic disease as underlying cause of death, and the effect of extreme heat or cold stress may be overlooked unless an effort is made to evaluate individual death certificates or medical examiners' records.

A procedure is proposed to avoid the current difficulties with cause of death classification by generation of a statistical standard of expected daily mortality for specific populations utilizing the available computer data base of vital statistics. A standard would be computed from a distribution of daily total mortality, without regard to cause of death.

A somewhat comparable technique is employed by the Centers for Disease Control, Atlanta, as developed by Collins (1952) to generate a standard of expected numbers of deaths from pneumonia and influenza in 121 urban centers. Increases beyond expected values are used to indicate the presence of influenza epidemics in specific populations; however, the data base employed is a special one, composed of all deaths attributed pneumonia or influenza without regard to classification as underlying or immediate.

3. RESULTS

The statistical standard proposed is a value of daily mortality corresponding to the 95th percentile of a distribution of appropriately selected non-heat wave or non-cold wave days. Choice of the 95th percentile was arbitrary, any percentile could be selected depending upon the severity of the limit desired. Excess mortality is defined as the difference between the daily observed mortality and the standard accumulated over the days of the heat or cold wave.

Table 3 illustrates the application of daily mortality standards to estimate excess mortality for states affected by the July 1966 heat wave. For each state, for 18 days corresponding to the heat wave, a distribution of 72 values of daily mortality was compiled representing 4 non-heat wave years. Listed alongside each state are the mean and 95th percentile of the non-heat wave years, the mean for the heat wave period, the total number of deaths classified as excessive heat (E.H.), total excess mortality for the heat wave - sum of observed minus 95% standard- (excess), and the highest temperature recorded for the period in the state.

Table 3. Daily total mortality for selected states in the United States for the period July 1 to 18.

	1962-1965 N=72		1966 - Heat Wave N=18			
State	Mean	95%	Mean	E.H.	Excess	Max. T(C)
ME	27	37	29	0	7	28.9
VT	12	20	11	0	0	36.7
NH	18	29	20	0	0	38.9
MA	143	176	163	0	63	36.1
RI	25	36	28	0	3	35.6
CT	66	83	75	2	53	37.2
NY	488	571	583	31	852	40.0
NJ	167	206	202	7	246	40.6
PA	327	378	382	12	441	39.4
DE	13	23	75	1	53	38.9
MD	79	94	92	1	100	38.3
DC	23	34	29	1	17	38.3
VA	91	107	104	2	48	35.6
WV	49	60	50	0	2	36.7
NC	103	123	117	0	22	37.2
SC	52	69	63	2	30	37.2
GA	92	109	107	1	79	34.4
FL	146	173	172	4	67	33.9
AL	82	97	91	7	51	38.9
MS	58	75	64	3	25	36.1
LA	86	114	93	1	7	35.1
TX	219	243	230	5	24	38.3
OH	253	290	279	3	175	37.2
KY	76	91	93	4	100	40.0
TN	90	108	104	18	117	39.4
MI	188	221	212	0	130	36.7
IN	121	143	147	10	175	37.2
IL	277	322	355	60	684	35.6
MO	129	151	205	170	978	40.6
AR	51	68	58	9	20	35.9
OK	67	80	70	2	6	41.7
MN	84	104	97	6	72	37.2
WI	102	127	115	3	86	36.1
IA	76	93	98	12	139	37.8
ND	15	23	15	0	0	36.7
SD	17	25	20	1	30	40.6
NB	39	51	48	7	56	37.2
KS	59	75	72	7	66	40.0
	4,010		4,768	392	5,024	

The extent of the July 1966 heat wave is evident in Table 3 by the numbers of excess deaths in all but three states. Clusters of deaths appear in the northeastern states and in the Mississippi Valley states, with a total of 5,024 for all states. A less rigorous standard, a percentile of 90% or 85%, would estimate an even larger loss of life. The study by Bridger and Helfand (1968) estimated 1,148 excess deaths for Illinois where Table 3 estimates 684, and a study by Buechley (1972) estimated an excess of 539 deaths for the New York City-Northern New Jersey Metropolitan area alone, where Table 3 shows a value of 852 for the entire State of New York. It may be the 95th percentile standard is too conservative, and the total loss of life for the heat wave may be well above 5,024.

Table 3 also illustrates the very low number of deaths certified as excessive heat (E.H.). The State of Missouri stands out with 170 deaths, but as mentioned, 135 deaths were certified in St. Louis alone due to the criteria for classification of heat stroke at that locality.

Table 4 concerns a late summer heat wave, August 27 to September 5, 1973.

Table 4. Daily total mortality for selected states in the United States for the period August 27 to September 5.

	1974-1977 N=40		1973 - Heat Wave N=10			
State	Mean	95%	Mean	E.H.	Excess	Max. T(C)
ME	26	37	30	0	0	30.0
VT	9	13	13	0	14	32.8
NH	18	25	23	0	16	35.0
MA	131	150	169	1	190	37.2
RI	23	31	29	0	16	34.4
CT	65	79	75	0	17	36.7
NY	428	474	578	18	1037	36.7
NJ	165	190	204	4	146	37.8
PA	299	334	372	11	386	37.8
DE	13	19	15	0	3	37.8
MD	83	97	103	10	79	37.2
DC	19	25	25	2	22	35.6
VA	99	118	109	2	16	35.6
WV	52	65	58	0	9	35.6
NC	117	135	122	1	23	34.4
SC	62	73	59	1	0	33.9
GA	107	122	113	0	8	35.0
FL	229	252	232	0	20	32.2
AL	86	102	87	0	3	34.4
MS	61	75	61	0	7	34.4
LA	87	100	81	0	5	33.9
TX	253	287	259	0	0	37.2
OH	245	271	301	4	303	35.6
KY	81	97	93	0	16	34.4
TN	98	116	106	0	18	35.6
MI	192	223	246	6	234	37.2
IN	122	138	131	0	8	35.6
IL	264	290	294	0	68	36.1
MO	124	141	136	0	23	33.3
AR	54	68	56	0	0	34.4
OK	68	79	64	0	0	33.9
MN	80	96	86	1	3	33.9
WI	98	113	119	0	78	37.2
IA	71	82	76	0	12	34.4
ND	14	21	16	0	0	41.1
SD	17	26	17	0	0	41.1
NB	36	44	39	0	1	33.9
KS	55	67	55	0	0	35.0
	4,051		4,544	61	2,781	

Heat-related mortality is usually associated with the first sudden rise in temperature in early summer, June or early July, before the human organism has had an opportunity to acclimatize or adjust its thermoregulatory system to the impact of heat stress. However, Table 4 shows patterns of excess mortality for states in the northeast and upper midwest during a 10-day period of maximum temperatures recorded near 37.0 C (98.6 F), August 27 to September 5, 1973. Using the 95th percentile of a distribution of daily mortality for a comparable 10-day period in 4 non-heat wave years, 1974 to 1977, as a standard maximum of 1,037 excess deaths were estimated for New York State, with a total of 2,781 deaths for all states. Certified excessive heat as cause of death for all states was recorded as only 61 cases.

Table 5 illustrates patterns of mortality associated with cold-wave conditions within the same selected states as studied in Tables 3 and 4. The period of 10-days began on January 25 and ended February 3, 1966, and represents the response of the population of the states to an outbreak of arctic air following a cold front through the Mississippi Valley and into the Gulf States and Florida.

Table 5. Daily total mortality for selected States in the United States for the period January 25 to February 3.

	1962-1965 N=40		1966 - Cold Wave N=10			
State	Mean	95%	Mean	E.C.	Excess	Min. T(C)
ME	34	43	31	0	0	-24.4
VT	14	21	13	0	0	-28.9
NH	22	29	19	0	0	-28.3
MA	175	218	185	0	0	-16.1
RI	28	38	27	0	0	-16.7
CT	76	95	84	0	6	-15.6
NY	537	599	551	1	28	-13.9
NJ	191	226	194	2	7	-14.4
PA	366	400	382	6	22	-23.3
DE	13	21	15	1	7	-15.0
MD	92	124	97	4	0	-13.9
DC	26	36	30	1	1	-12.8
VA	109	135	119	10	0	-16.1
WV	54	66	56	3	9	-22.8
NC	119	142	136	10	22	-16.1
SC	66	80	74	4	18	-21.1
GA	112	139	137	6	52	-20.0
FL	159	183	194	1	156	-11.7

(Table 5 continued)

State	Mean	95%	Mean	E.C.	Excess	Min. T(C)
AL	95	117	108	5	43	-23.9
MS	69	85	84	5	63	-14.4
LA	89	105	104	1	37	-10.6
TX	245	300	271	4	69	-21.1
OH	278	317	291	4	14	-23.3
KY	92	106	97	1	19	-24.4
TN	104	126	107	8	3	-23.3
MI	201	242	214	1	0	-24.4
IN	135	158	135	1	1	-23.9
IL	317	345	329	4	63	-28.9
MO	151	174	157	2	3	-25.0
AR	58	70	61	3	13	-16.7
OK	72	87	78	0	4	-17.2
MN	93	110	93	1	2	-35.0
WI	111	137	112	3	0	-31.7
IA	84	100	85	1	0	-32.2
ND	15	24	16	2	0	-40.0
SD	18	28	15	1	0	-34.4
NB	42	50	42	1	8	-27.8
KS	66	82	65	0	0	-23.9
	4,528		4,807	97	670	

The same technique is employed as in a heat-wave situation with the 95th percentile of a comparable 4-year non-cold wave period used as a standard for expected daily mortality in each state. A column of certified excessive cold deaths (E.C.) replaces the column of excessive heat data contained in Table 3 and Table 4. A cluster of excess deaths appears in the Gulf Coast states and southeastern states with a maximum of 156 occurring in Florida, with conditions cold enough for freeze damage in southern Florida. A total of 670 excess deaths is estimated for all states for the 10-day period, with only 97 certified as cold related on death certificate records as underlying cause.

Weather conditions in the northeastern United States were characterized by an outbreak of cold, dry arctic air behind a rapidly moving cold front on January 6, 1973. This was the first sudden drop in temperature for the winter of 1972 - 1973, and the response of an unacclimatized population may be observed in Table 6.

Table 6. Daily total mortality for selected states in the United States for the period January 6 to 15.

State	1974-1977 N=40 Mean	95%	1973 - Cold Wave N=10 Mean	E.C.	Excess	Min. T(C)
ME	29	40	31	0	0	-24.4
VT	12	17	13	0	4	-27.2
NH	22	30	21	0	0	-27.8
MA	164	191	191	1	33	-17.2
RI	27	35	32	0	16	-15.6
CT	76	89	85	1	18	-17.2
NY	501	551	571	2	230	-11.7
NJ	193	213	225	1	138	-11.1
PA	360	405	400	4	102	-11.1
DE	14	20	16	0	2	-10.6
MD	96	113	103	0	18	-11.1
DC	22	32	26	0	0	-15.0
VA	117	140	127	0	5	-15.0
WV	57	70	63	1	6	-15.0
NC	139	159	154	7	27	-15.0
SC	74	90	79	3	0	- 7.8
GA	128	149	140	3	18	- 8.9
FL	261	303	264	2	0	- 1.7
AL	105	128	109	0	6	-10.0
MS	69	85	79	0	3	-10.6
LA	100	116	119	1	53	- 6.1
TX	306	346	337	3	58	-10.0
OH	283	311	300	0	64	-12.8
KY	103	125	101	1	1	-11.7
TN	117	142	116	2	0	-13.3
MI	219	239	236	2	32	-13.9
IN	144	169	152	1	2	-15.6
IL	318	354	357	1	100	-17.2
MO	154	178	164	3	1	-17.2
AR	68	81	68	0	0	- 9.4
OK	87	100	85	3	0	-18.3
MN	99	129	97	2	0	-28.9
WI	118	142	125	3	3	-20.0
IA	89	116	85	1	0	-23.3
ND	16	25	15	0	0	-35.0
SD	19	30	19	3	0	-28.3
NB	44	56	47	0	0	-25.0
KS	70	84	73	1	10	-21.7
	4,820		5,225	52	950	

A maximum of 230 excess deaths were determined for the State of New York, with numbers of 100 and higher in New Jersey, Pennsylvania, and Illinois. A snow and ice storm developed on January 11 and 12 over Texas and Louisiana following the arrival of the cold air, the first experience of severe winter conditions for this region. Ice storms also occurred in Georgia, January 7 to 9, and North Carolina, January 8 to 11. Florida remained in the warm sector of this storm and the number of excess mortality (0) listed in Table 6 for this state reflects the lack of severe cold conditions during these 10 days.

4. SUMMARY

The term excess mortality infers a number of deaths that would not have occurred had there been no heat or cold wave episode. Although there is a specific cause of death assigned to

occurrences of excessive heat or cold, these designations are used so rarely as the official underlying cause of death on death certificates other methods must be employed to estimate loss of life associated with these events. A most commonly used method is to find a reference or non-heat wave period for the population under study and conclude the mortality observed was an expected value and any amount greater observed during the heat wave epidode was excess mortality. This study utilizes a computer data base to determine a distribution of daily mortality for populations during non-heat or non-cold wave conditions and select and test a statistical standard, the 95th percentile, as a limit above which excess mortality begins. When this standard was tested for two heat wave and two cold wave episodes, it appeared sensitive to both the particular populations and the variations in weather conditions across the states. There was an indication that the 95th percentile might be too rigorous a limit and the 90th and 85th percentile might be more reliable, in which case estimated deaths would be greater than indicated.

Although mortality data for entire states were used in this study, a standard could be found for particular county, city or region that has file of past daily mortality. If non-heat and non-cold wave days could be identified, then standards could be produced in anticipation of the episodes, and the response of the population monitored from day to day to detect and measure the effect of extreme weather conditions.

DISCLAIMER - This is an extended abstract of a proposed presentation and does not necessarily reflect EPA policy.

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